A PRACTICAL METHOD OF REFERRING UNITS OF LENGTH TO THE WAVE LENGTH OF SODIUM LIGHT.

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During the summer of 1890 Professor Morley, of Adelbert College, suggested to the writer a method of determining the co-efficient of expansion of a bar of metal between the limits of the freezing and the boiling points expressed in wave lengths of light having a known refrangibility. After a discussion of the best form of apparatus required for this purpose, it was arranged that I should construct this apparatus, that he should come to Waterville during his summer vacation and that we should jointly undertake the experiment.

It will be sufficient to give in this paper a general outline of the method and of the principle upon which it rests.

In the accompanying sketch *A* and *B* are bars of metal, placed upon supports which move at right angles to each other between guides (not shown in the figure.) The support upon which *A* rests is moved by a combined wedge and screw in order to obtain a movement which is well under the control of the observer. The index wheel is at the right of the observer and within easy reach. *B* is placed at right angles to *A* upon a plate which has slight longitudinal motion. The silvered plane-surface mirrors *a* and *á* are supported upon three points at the ends of the *A* and *B*. The mirrors *b* and *b′* are similarly mounted at the other ends. One of the three points of support is a rounded projection from the end of the bar itself. The mirrors are first of all set at right angles to the axis of the bars by means of a collimating eye piece by the aid of screws whose counter end-thrust is controlled by springs.

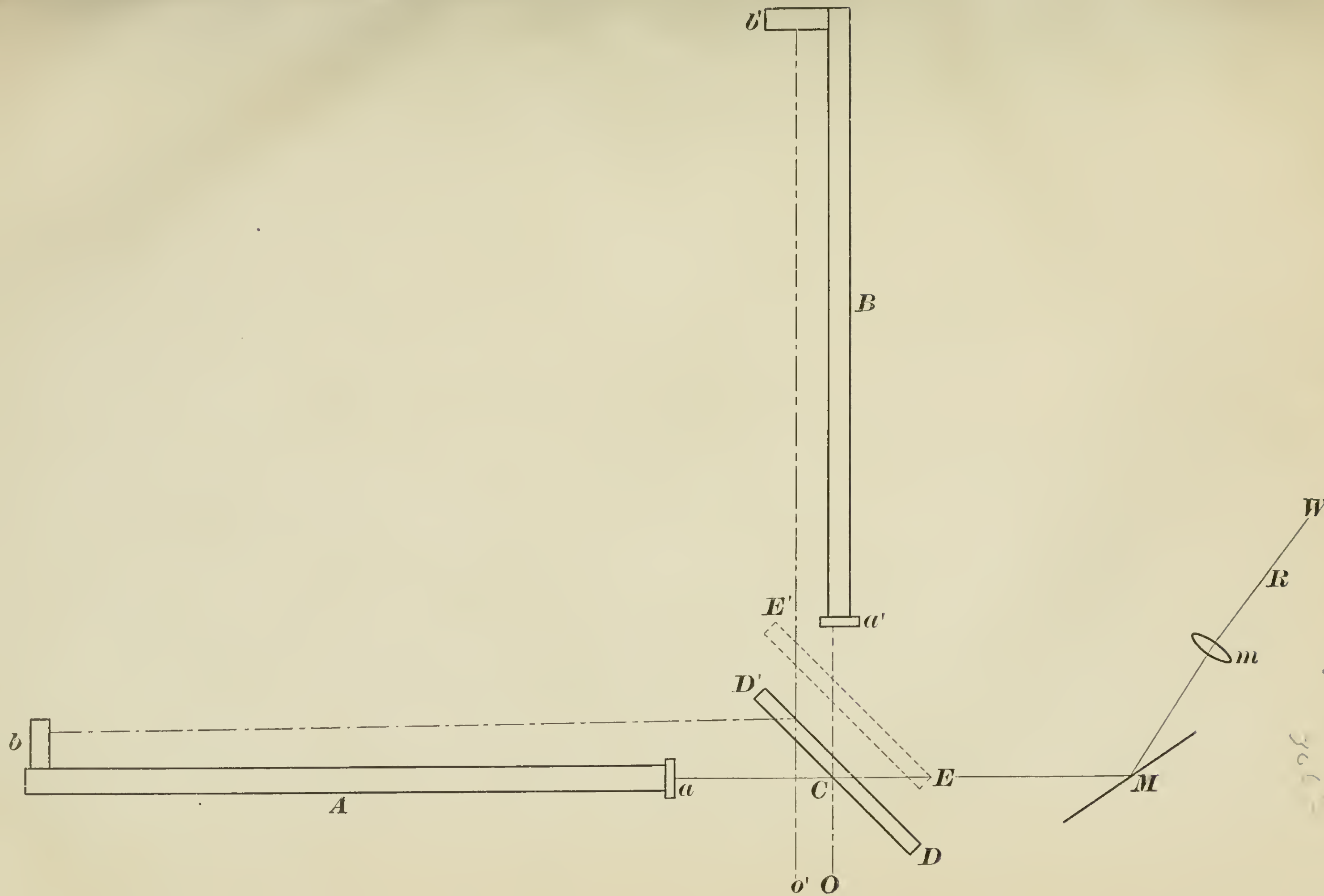
DD is called the diagonal mirror. It is placed at the intersection of *ac* and *ác*. This mirror is half silvered, that is, the process of silvering is continued until one-half the light which strikes the mirror will be transmitted and the remaining half reflected. *EÉ* is a plane unsilvered mirror having parallel faces. It is called the "evener" since it permits the passage of both the transmitted and the reflected rays through the same thickness of glass.

M is a plane-reflecting mirror, *m* is a condensing lens having cross wires at the center. *R* is a sodium flame and *W* is a lamp flame placed in the line *mR*.

One-half of a ray from *R* is transmitted through the mirror to *a*. This is in turn reflected back to *b*. One-half of this reflected ray passes through the glass. The other half suffers internal reflection and is seen by the observer at *O*.

The reflected half of the original ray is reflected back to *b*. At this point it divides again and the transmitted half reaches the point *O'*. Now of the two rays which reach the eye at *O*, or *O'*, the first has suffered in internal reflection and the second external reflection. They therefore differ by half a wave length. This condition will always exist when *ba* equals *bá* nearly. When therefore the cross at *m* on the condensing lens is seen to be coincident with its image in the telescope at *O*, the field will be filled with dark lines about one ninety-thousandths of an inch apart. These lines of course result from the absence of light from the monochromatic yellow flame at the points at which the rays differ by half a wave length. If now a white light be placed behind *R* at *W*, a condition will be obtained in which one line, or as it is commonly called one fringe, will be black and the remaining fringes will take the colors of the rainbow. This condition will be obtained when the distance *ba* is *exactly* equal to *bá*, a result which can be secured by moving the plate upon which *A* rests by means of the screw. In the same way the sodium line in white light will be seen at *O'* when the distance *bb* is *exactly* equal to *b'b'*.

The method of observation is as follows: A fiducial line is drawn in india ink upon the mirror directly over the fulcrum about which the mirror moves. The fringes in white light are first formed upon the rear mirror and the sodium line in white light



b'
B
E'
a'
W
R
m
D'
b
E
a
C
M
A
D
o'
O

is set in coincidence with the fiducial line upon the mirror. The telescope is then moved to *O*. If now the sodium line in white light is found to be coincident with the fiducial line upon the front mirror the two bars have *exactly* the same length. If it does not occupy this position the plate *A* is moved along by means of the screw until the dark line does appear in coincidence; the corresponding number of sodium lines being counted during the movement from one coincidence to the other. In my experience, it is found easy to count about 90 fringes per minute for short runs. I have frequently counted 700 lines in 10 minutes. It will be found convenient to turn off the white light during the greater part of the time occupied in counting, using only the sodium lines for counting till the end is nearly reached when both lights must be in the same field of view.

The feasibility of this method was proven by the observations made by Professor Morley and myself in 1891. Both bars were observed for half a day in melting ice, the difference in length remaining constant meanwhile. The ice surrounding the bar *B* was then removed and the bar was kept in steam for several hours. Under this condition, also, the difference in length between the two bars was measured. In this experiment, however, it was found impossible to count the corresponding number of fringes on account of the impossibity of obtaining sufficient freedom from the condensation of moisture upon the mirrors, although the fringes were seen upon both mirrors under the extreme conditions of temperature. Hence the only thing which could be done was to measure the distance by means of a microscope attached to the plate upon which the bar *A* is placed, the scale being disconnected from this plate.

These experiments made it clear that all observations of this character must be made in vacuo.

A new refractometer was therefore constructed. In doing this several improvements were introduced. The bars were enclosed in boxes of rolled brass, as it was supposed that the air could not enter the boxes through the pores of this metal. In this I was disappointed and after a trial of over a year, it was found